DOCUMENT RESUME

ED 221 393 SE 039 205

AUTHOR Arasmith, E. E.
TITLE Jar Test. Operational Control Tests for Wastewater Treatment Facilities. Instructor's Manual [and] Student Workbook.
INSTITUTION Linn-Benton Community Coll., Albany, Oreg.
SPONS AGENCY Office of Water Program Operations (EPA), Cincinnati, Ohio. National Training and Operational Technology Center.
PUB DATE Apr 82
GRANT EPA-900953010
NOTE 69p.; Slide/tape program which accompanies this module is also available from Linn-Benton Community College along with a video cassette.
AVAILABLE FROM Linn-Benton Community College, 6500 S.W. Pacific Blvd., Albany, OR 97321 ($1. student workbook, $2. instructor's guide).

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Chemical Analysis; Instructional Materials; *Laboratory Procedures; Postsecondary Education; Sludge; Teaching Guides; *Training Methods; *Waste Water; *Water Treatment
IDENTIFIERS Jar Test

ABSTRACT

The jar test is used to determine the proper chemical dosage required for good coagulation and flocculation of water. The test is commonly used in potable water, secondary effluent prior to advanced wastewater treatment, secondary clarifier influent, and sludge conditioning practice. Designed for individuals who have completed National Pollutant Discharge Elimination System (NPDES) level 1 laboratory training skills, this module provides waste water treatment plant personnel with the basic skills and information needed to: (1) successfully run the jar test; (2) accurately record data and observations; and (3) determine proper chemical dosages and mixing times for proper coagulation and flocculation. The teacher's manual contains a statement of instructional goals, lists of instructor/student actitivies and instructional materials, instructional strategies on preparing stock solutions, overhead transparency masters, and student worksheet (with answers). The student manual contains objectives, prerequisite skills needed before starting the module, sources of jar test units, laboratory procedures, and worksheet. (Author/JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED221393

Operational Control Tests

for Wastewater Treatment Facilities

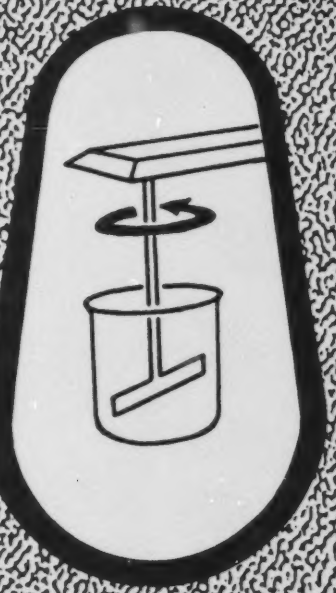
U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

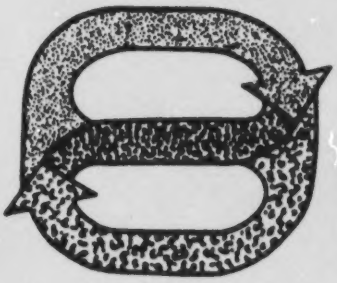
Jar Test

Instructor's Manual



SE039205

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
John W. Carnegie
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."



Linn-Benton Community College
Albany, Oregon

JAR TEST

Written By:
E. E. Arasmith
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Project Management
John W. Carnegie, Ph.D.
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under
EPA Grant #900953010
August, 1981

JAR TEST

CONTENTS

Subject	Page
Instructional Goals	Jt-1
Instructor Activity	Jt-1
Student Activity	Jt-1
Instructional Materials List	Jt-2
Appendix Introduction	Jt-3
Appendix A	
Stock Solution From Dry Chemicals	Jt-4
Appendix B	
Stock From Concentration Solution	Jt-7
Appendix C	
Stock Solution From Both Mix Dry Feeders	Jt-13
Appendix D	
Stock Solution From A Liquid Batch Mix	Jt-19
Answers to Worksheet	W-Jt-2
Student Materials	S-Jt-1 thru 27
	SW-Jt-1 thru 2

INSTRUCTIONAL GOALS

Upon completion of this lesson you should be able to successfully run the jar test and accurately record the data and observations.

INSTRUCTOR ACTIVITY

For best results follow this sequence:

	Activity	Time
1.	Review the objectives with the students.	5 minutes
2.	Have the students read through the procedure.	10 minutes
3.	View the video tape, "Jar Test Procedure".	70 minutes
4.	Demonstrate the procedure.	15 minutes
5.	Assign the worksheet.	15 mintues
6.	Correct the worksheets.	5 minutes
7.	Perform the test.	120 minutes

OTHER ACTIVITIES:

1. If time permits, have the students experiment with various combinations of primary coagulant lime and polyelectrolytes. Each combination could take from 30 minutes to an hour.
2. Also, if time allows have the students perform the test on several different types of samples.
3. If you have time, practice calculating dosage requirements. (See Student Materials - Supplementary Materials, Part I and Appendixes A, B, C and D.)

STUDENT ACTIVITIES

1. Read the objectives.
2. Read the procedure.
3. View the video tape "Jar Test Procedure".
4. Complete the worksheet.
5. Perform the test.
6. Record the data.

INSTRUCTIONAL MATERIALS LIST

1. Instructor's Guide "Jar Test"
2. Student Workbook "Jar Test"
3. 3/4" cassette video tape player
4. Color television set
5. Overhead projector
6. Projector screen
7. Visa-Visa pens and acetate for overhead projector
8. Blackboard and chalk
9. Equipment listed in the lab procedures

APPENDIX INTRODUCTION

The preparation of stock solutions continues to be a difficult task even for those individuals with some background in solution preparation. Therefore, we have developed the following procedures to help you in teaching the procedures.

These four appendixes will follow the Supplementary Materials in the Student Workbook. You may not need to go through all four procedures. Poll the students to find their needs; then cover only the needed procedures.

APPENDIX A

STOCK SOLUTION FROM DRY CHEMICALS - used with page S-Jt-7, Student Workbook (Supplementary Materials).

This is a straightforward procedure and only requires the weighing of the reagent and then dissolving the reagent in distilled water in a volumetric flask. The flask is then filled with distilled water until you reach the full mark. The reagent must be taken from the chemicals that are being fed at the plant. New stock should be made each time a new batch of chemicals is used.

OH#1 - This overhead shows the step by step procedure for making the reagent.

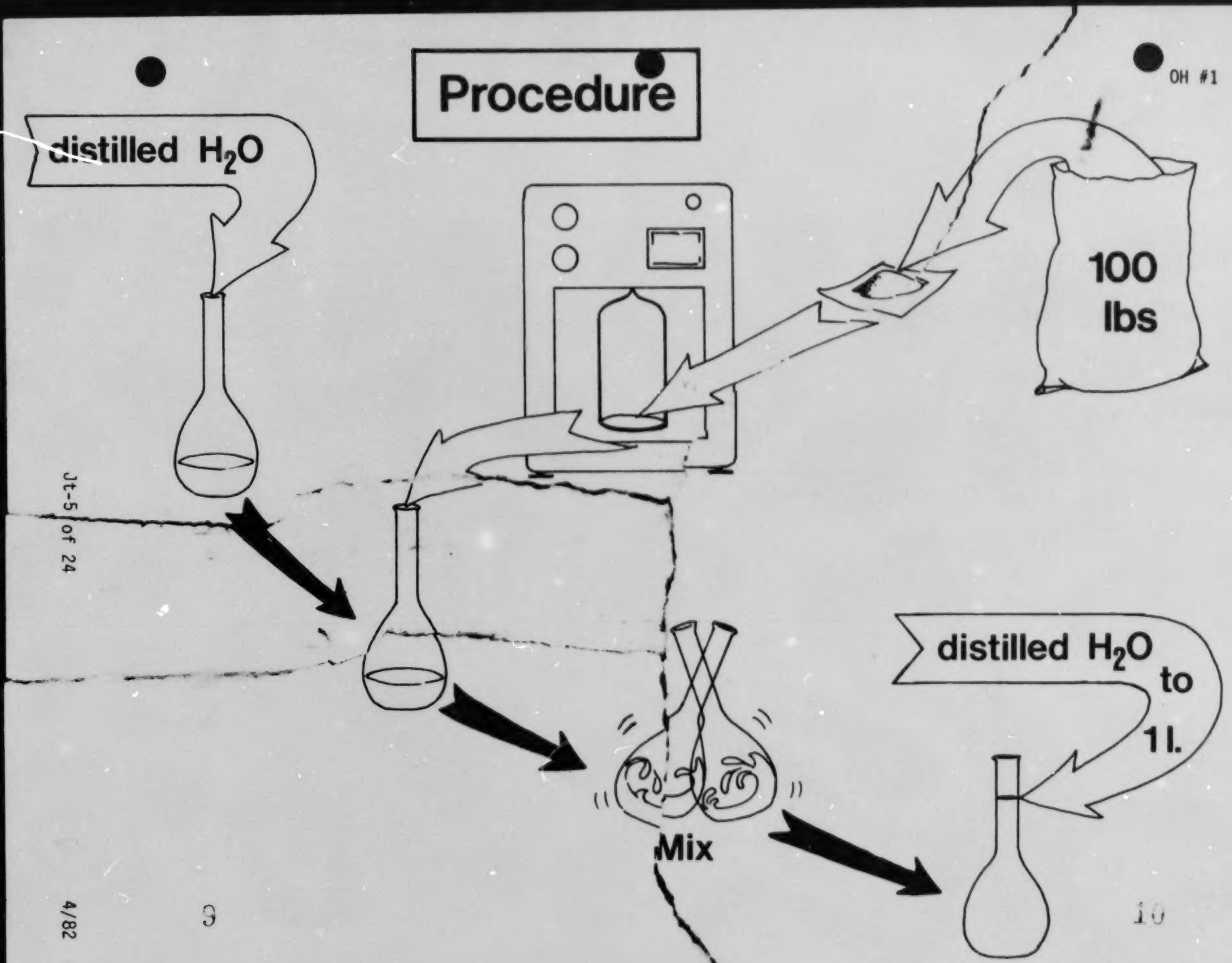
The procedure is as follows:

1. Assume a dosage requirement.
2. Select the amount of chemical needed (column 2, table on OH#2)
3. Obtain a sample of chemical being fed.
4. Weigh to the nearest 0.1 g.
5. Place 200 ml of distilled H_2O in the volumetric flask.
6. Transfer dry chemical to volumetric flask.
7. Mix until dissolved.
8. Dilute to 1 liter with distilled water.
9. Transfer to storage bottle.

OH#2 - This is an overhead of the amount of chemicals needed to obtain a set dosage.

Notice that the lab technician must start by assuming a dosage range. Next, the amount of chemical to make one liter is found. The final data is the concentration of the stock solution. Column 3 gives the dosage received from each 1 ml of stock when it is placed in 1 liter of sample.

Procedure



1	2	3	4
APPROX. DOSAGE REQUIRED, ML/L	GRAMS/LITER TO PREPARE	1 ML ADDED TO 1 LITER SAMPLE EQUALS	STOCK SOLUTION CONC., MG/L (%)
1-10 MG/L	1 G/L	1 MG/L	1,000 MG/L (0.1%)
10-50 MG/L	10 G/L	10 MG/L	10,000 MG/L (1%)
50-500 MG/L	100 G/L	100 MG/L	100,000 MG/L (10%)

APPENDIX B

STOCK FROM CONCENTRATED SOLUTION

Solutions of Alum, Ferric Chloride, Ferric Sulfate, and other concentrated solutions require the use of the specific gravity of the solution in order to determine the exact concentration.

When specific gravity (Sg) is not known it can be found be weighing a known volume of the solution and comparing it to the weight of water. (See Student Supplementary for more details.)

Although there are other more scientific methods of dealing with this type of problem we find this to be one of the two most acceptable methods. The other that is a gross measurement will yield acceptable results but will not give absolute data about concentration. This rough method uses a straight dilution. That is if you want 1 liter of 1% solution, simply use a pipet to obtain 10 ml (0.01 X 1000 ml = 10 ml) of the stock. Place this in a 1 liter volumetric flask and dilute with distilled H_2O.

Remember that 1% is equal to 10,000 mg/l.

OH#3 - The procedure for using Sg and percent concentration to make a stock solution.

The Procedure

1. Determine the specific gravity of the feed solution - OH#4.
2. Determine the needed concentration of stock solution. This may be done by using the table on OH#2. The key element is making an estimation of the approximate dosage required.
3. Calculate the volume of feed solution necessary. Use OH#5.
4. Obtain the required volume of feed solution.
5. Transfer this volume to a one liter volumetric flask.
6. Dilute to one liter with distilled water.

OH#4 - Specific gravity calculations.

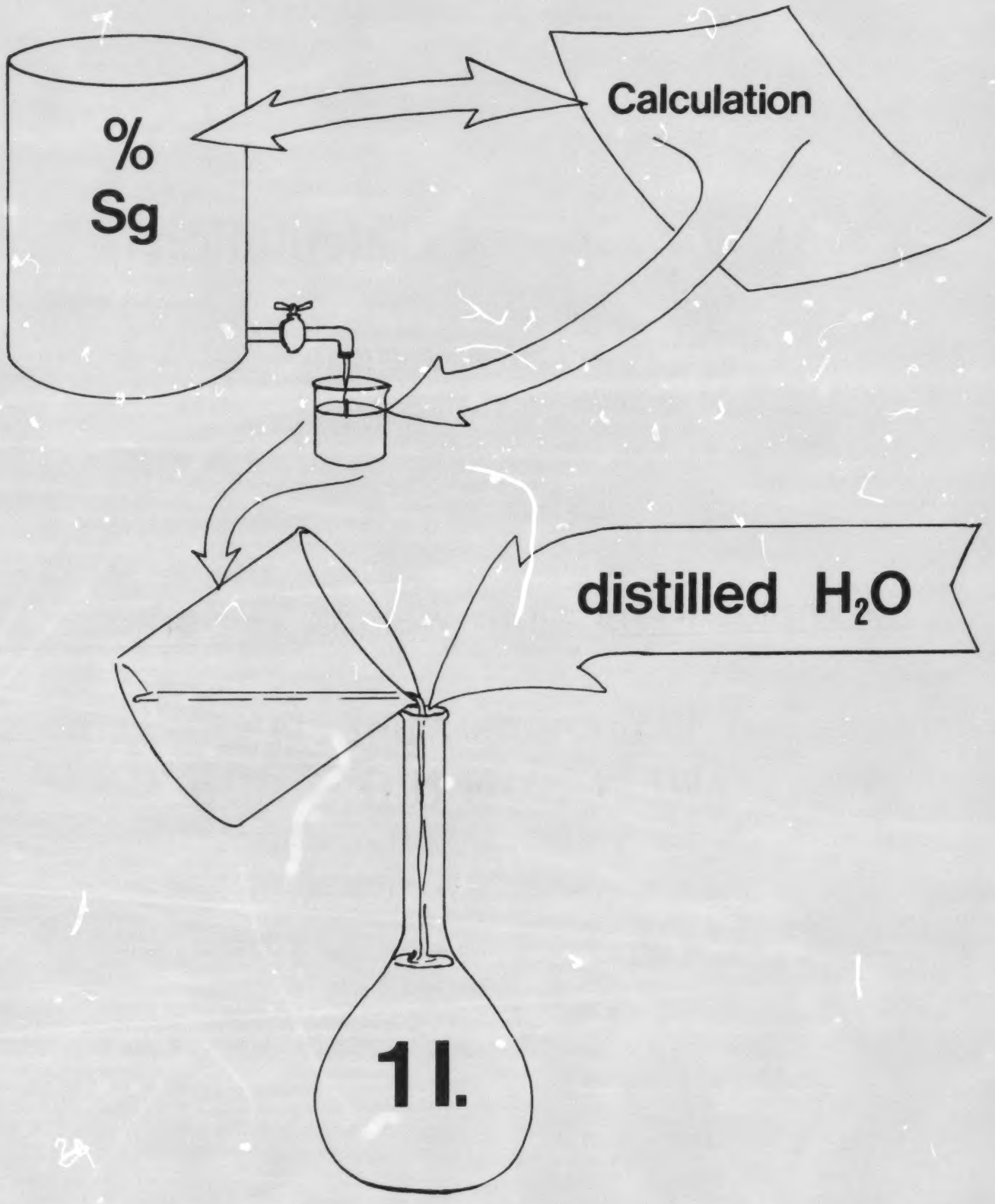
OH#5 - Calculations for determining the volume of feed solution necessary for 1 liter of stock solution.

OH#5 - The gross measurement method.

Presentation Procedure

1. Go through the procedure using OH#3. Point out that the procedure requires 2 calculations (specific gravity and volume of feed) and one assumption (concentration of stock needed).
2. Use OH#4 to go through an example of the specific gravity calculations.
3. Use OH#5 to go through an example of calculations for volume of stock needed.

OH #3



OH #4

Specific Gravity Calculation

$$\frac{\text{wt. of known volume}}{\text{wt. of equal volume } H_2O} = Sg$$

Example: 10 ml alum weighs 13.5 grams

$$\frac{\text{13.5 grams alum}}{\text{wt. of 10 ml } H_2O} = \frac{13.5\,g}{10\,g}$$

$$Sg = 1.35$$

Volume of feed solution to make stock solution:

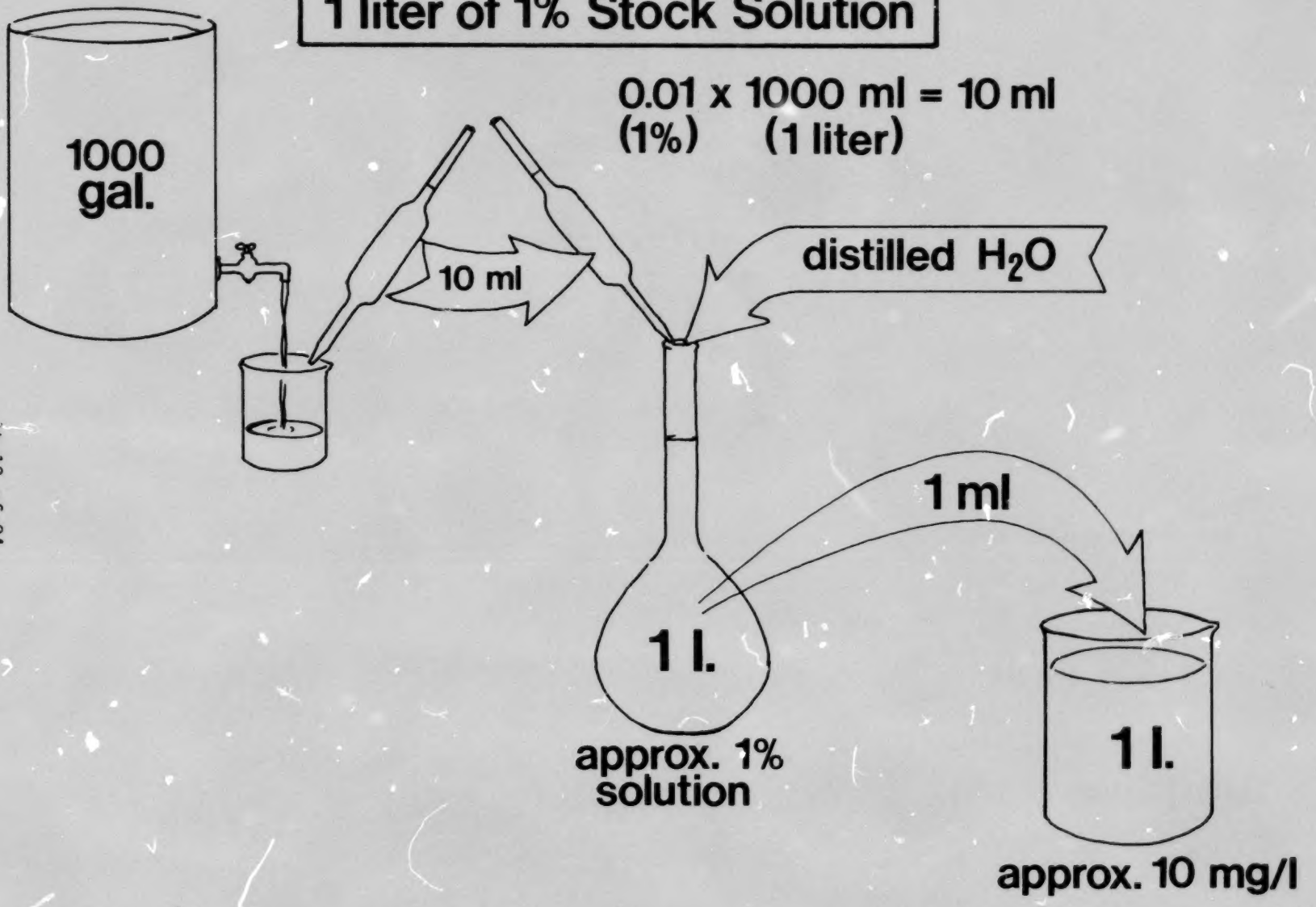
$$\text{ml needed} = \frac{\text{\_\_\_\_\_\% stock x \_\_\_\_\_ml of stock}}{\text{\_\_\_\_\_Sg x \_\_\_\_\_\% conc.}}$$

Example: Make 1l of 1% stock solution.

Feed is 17% with Sg 1.35

$$\frac{1\% \times 1000\ \text{ml}}{1.35 \times 17\%} = 43.6\ \text{ml}$$

Alternate Method
1 liter of 1% Stock Solution



APPENDIX C

STOCK FROM BATCH MIX DRY FEEDERS

Making stock solutions from a batch process nearly always gives operators problems. There are three approaches that we have used to help overcome some of the difficulties. The most operator acceptable method uses overheads 7, 8, 2, and 9. This method is one adaption of the common $V_1C_1 = V_2C_2$ calculation but is layed out as a job aid rather than an equilibrium equation.

The Procedure

1. Cover the bottom half of overhead #7. This is the classic pound formula solving for concentration.
2. Go over the equation then move down the overhead uncovering the calculations as you go. The answer has been rounded off to 120,000 mg/l for convenience.
3. Using overhead #8 point out that we have assumed a concentration of 10 mg/l per ml dosage in the jar test for each ml of stock added. Should you decide that some other concentration per ml is needed this would only change the needed concentration of the stock. The concentration of the needed stock is found from the table on OH#2. The real concern is the volume of feed (V_2) needed for the stock.
4. Determine the concentration of the stock (V_3) from the table in OH#2.
5. Use overhead #9 to show the procedure for calculating the ml of feed solution necessary to make 1 liter of 10,000 mg/l stock.

The second method is more classic and requires using the standard $V_1C_1 = V_2C_2$ approach. Use overheads 7, 8 and 10. This method will be better accepted by the lab technician because he/she can see what is happening.

The Procedure

1. The first portion of the procedure is the same as above. Use OH#7 to determine the concentration of the feed solution.
2. Use OH#8 to show the values needed. The trick here is again to assume a concentration in the jar test.
3. Use OH#10 (top half) to show the procedure for calculating the needed concentration of stock. (10,000 mg/l)
4. Finally, using OH#10 (bottom half) calculate the volume of feed necessary to produce a 10,000 mg/l stock.

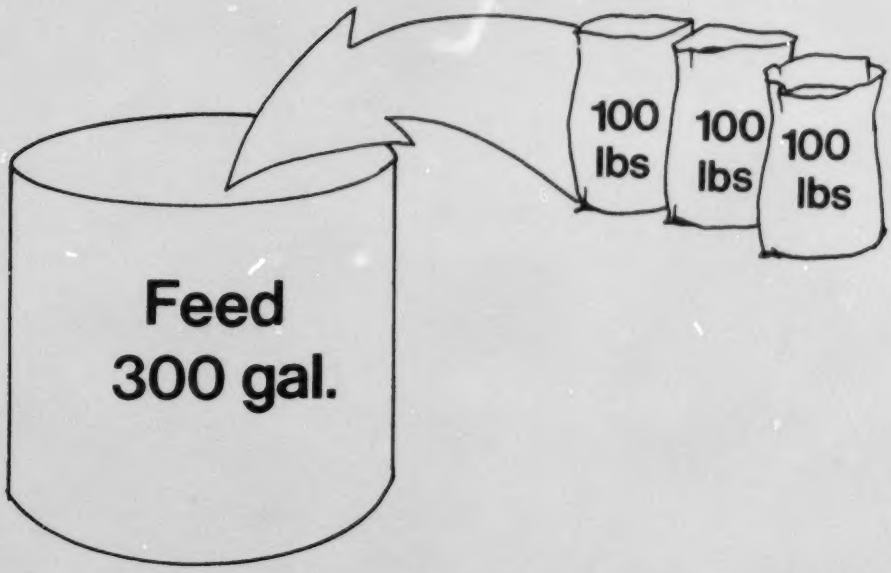
OH#7 - Calculations for concentration of batch solution. Concentration expressed in mg/l.

OH#8 - A flow chart showing the steps required in making the stock.

OH#9 - Calculations for determining the amount of batch solution necessary to make a given concentration of stock.

OH#10 - Calculation for volume of batch needed, using the $V_1C_1 = V_2C_2$ approach.

OH #7



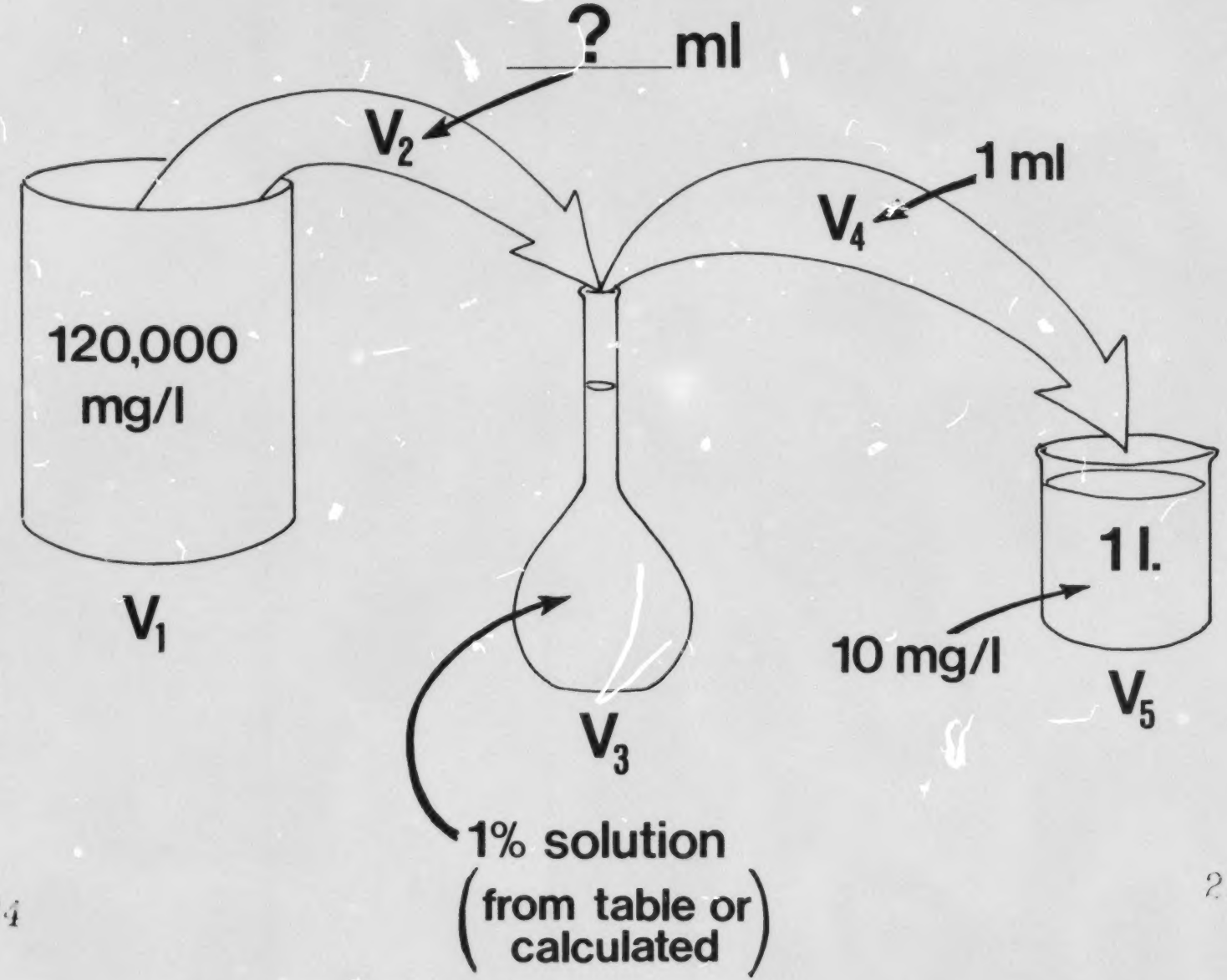
$$\text{Conc. mg/l} = \frac{\text{\_\_\_\_\_ lbs. chemical x 1,000,000}}{\text{\_\_\_\_\_ gal. } H_2O \text{ x 8.34 lbs/gal.}}$$

$$= \frac{300 \text{ lbs. x } 1{,}000{,}000}{300 \text{ gal. x } 8.34 \text{ lbs./gal.}}$$

$$= 119{,}000 \text{ mg/}$$

OR

120,000 mg/l


? ml
V2
1 ml
V4
120,000
mg/l
V1
1 l.
10 mg/l
V5
V3
1% solution
(from table or
calculated)

$$\text{Vol. of ml needed} = \frac{\text{conc. of stock, mg/l x 1000 ml}}{\text{conc. of batch, mg/l}}$$

$$\text{\_\_\_\_\_ml} = \frac{10{,}000 \text{ mg/l x } 1{,}000 \text{ ml}}{120{,}000 \text{ mg/l}}$$

$$= 83 \text{ ml}$$

$$V_4 C_4 = V_5 C_5$$

$$1\,ml \times C_4 = 1{,}000\,ml \times 10\,mg/l$$

$$C_4 = 10{,}000\,mg/l$$

$$V_2 C_2 = V_3 C_3$$

$$V_2 \times 120{,}000\,mg/l = 1{,}000\,ml \times 10{,}000\,mg/l$$

$$V_2 = 83\,ml$$

APPENDIX D

STOCK FROM A LIQUID BATCH MIX

As with the dry mix batch process this is a simple dilution problem that has enough stops in it to lose most operators. We would suggest that you use one of two processes when teaching this technique. The job aid methods for those individuals that only do this task ocassionally (use OH#'s 11, 12, 2 and 3).

The Procedure

1. Use OH#11 to show how to calculate the concentration of feed solution (200,000 mg/l) this is an adaption of the pound formula.
2. Using OH#12, point out that the first step is to determine by experiment or assumed from past experience a dosage range in the jar test (V_5).
3. Once a dosage range has been established in concentration of the stock can be found using OH#2.
4. Using OH#13, go over the procedure for calculating the volume of feed (V_2) necessary to make 1 liter of a 10,000 mg/l stock.

The $V_1C_1 = V_2C_2$ approach for those who may routinely need to make dilutions; use OH#'s 11, 12 and 14.

The Procedure

1. Use OH#11 to determine the concentration of the feed solution (200,000 mg/l). This is an adaption of the pounds formula.
2. With OH#12 point out that a concentration of V_5 for the jar test must be assumed before proceding. Then the process is to determine the concentration at V_3 and V_2 respectfully.
3. Use OH#14 to go over the procedure for determining first the concentration of the stock (10,000 mg/l), then...

4. using the newly calculated concentration for the stock, determine the volume of feed (50 mg/l) needed.

OH#11 - Calculations for determining the concentration of liquid in the batch.

OH#12 - Flow diagram of procedure.

OH#13 - Calculations for determining the volume of batch feed needed to make 1 liter of 10,000 mg/l stock.

OH#14 - Calculations for making a 10,000 mg/l stock using the $V_1C_1 = V_2C_2$ approach.

$$\text{Vol. of mls needed} = \frac{\text{conc. of stock, mg/l} \times 1000 \text{ ml}}{\text{conc. of batch, mg/l}}$$

$$\text{\_\_\_\_\_ml} = \frac{10{,}000 \text{ mg/l} \times 1{,}000 \text{ ml}}{200{,}000 \text{ mg/l}}$$

$$= 50 \text{ ml}$$

Concentration of Stock Needed

$$V_4 C_4 = V_5 C_5$$

$$V_4 \times 1 \text{ ml} = 1{,}000 \text{ ml} \times 10 \text{ mg/l}$$

$$V_4 = 10{,}000 \text{ mg/l}$$

Volume of Batch for 1 Liter Stock

$$V_2 C_2 = V_3 C_3$$

$$V_2 \times 200{,}000 \text{ mg/l} = 1{,}000 \text{ ml} \times 10{,}000 \text{ mg/l}$$

$$V_2 = 50 \text{ ml}$$

JAR TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. In order to perform the jar test you should collect a sample volume of:

   a)_____ 2 1/2 gallons.
   b)__X__ 5 gallons.
   c)_____ 2 1/2 liters.
   d)_____ 5 liters.
   e)_____ All of the above.

2. When the actual plant data is not available, flash mix in the jar test should be for how much time?

   a)__X__ 5 minutes
   b)_____ 10 - 30 seconds
   c)_____ 5 - 30 minutes
   d)_____ 1 - 8 minutes
   e)_____ None of the above.

3. Which one of the following is in correct sequence?

   a)__X__ Turn on the flash mix, then add chemicals.
   b)_____ Add the chemicals then turn on the flash mix.
   c)_____ Slow stir then flash mix.
   d)_____ Flash mix then slow stir.
   e)_____ All of the above.

4. When plant data is not available, the slow stir time should be approximately:

   a)_____ 10 - 30 seconds.
   b)_____ 30 - 60 minutes.
   c)_____ 20 - 40 minutes.
   d)__X__ 15 - 30 minutes.
   e)_____ All of the above.

5. A low alkalinity water is one in which the alkalinity is below:

a)_____ 40 mg/l.
b)_____ 7 grains/gallon.
c)_____ 150 mg/l.
d)__X__ 80 mg/l.
e)_____ None of the above.

6. Which item is the most influencial in determining the proper chemical dosage?

a)_____ Alkalinity
b)__X__ pH
c)_____ Temperature
d)_____ Presence of salts
e)_____ None of the above.

7. Normally, as the solids concentration or turbidity of water increases the amount of chemicals necessary to obtain adequate coagulation:

a)_____ stays the same.
b)__X__ goes up.
c)_____ goes down.
d)_____ can go either up or down.
e)_____ None of the above.

Operational Control Tests

for Wastewater Treatment Facilities

Jar Test

Student Workbook

SE039205

Linn-Benton Community College
Albany, Oregon

JAR TEST

Written By:
E. E. Arasmith
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Project Management
John W. Carnegie, Ph.D.
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under
EPA Grant #900953010
August, 1981

JAR TEST

CONTENTS

Subject	Page
Introduction	S-Jt-1
Objectives	S-Jt-1
Prerequisite Skills	S-Jt-1
Resource List	S-Jt-1
"Jar Test" Procedure	S-Jt-3
Supplementary Materials	
Preparation of Stock Solutions	S-Jt-7
Text Material	S-Jt-10
"Jar Test" Test Data Sheet	S-Jt-25
Sample Data Sheet	S-Jt-26
Procedure Summary	S-Jt-27
Worksheet	SW-Jt-1

INTRODUCTION

This module on the jar test is intended to give the operator those skills necessary to actually determine proper chemical dosages and mixing times for proper coagulation and flocculation of water. The mention of any brand names should not be taken as an endorsement of that material.

This module is intended to be used by individuals who have completed the NPDES level I Laboratory skills training.

OBJECTIVES

Upon completion of this module you should be able to:

1. Recall the volume of sample needed.
2. Recall the approximate stir times.
3. Describe the influence of alkalinity, pH, solids and temperature on chemical concentrations.
4. Perform the jar test.

PREREQUISITE SKILLS

In addition to the skills listed in the introduction, the following skills are needed for this test:

1. Ability to use a timer clock.
2. Ability to use a turbidimeter.
3. Ability to measure alkalinity.
4. Ability to use a pH meter.

RESOURCE LIST

Jar test units may be purchased from:

1. VWR Scientific
   P.O. Box 3551
   Seattle, WA 98124

   Stirrer, Multiple,
   Water Analysis
   Cat. #58968-102

2. VWR Scientific
   P.O. Box 232
   Boston, MA 02101

RESOURCE LIST (Continued)

3. Nurnberg Scientific Co.
   124 Livingston St.
   Brooklyn, NY 11201

   Six paddle variable speed mixer
   Cat #55630
   Light table for the above
   Cat. #55631

4. Hach Chemical Co.
   P.O. Box 907
   Ames, IA 50010

   Floc - tester
   Cat. #15057-00

Further information on the performance of this test may be found by obtaining the following written material:

1. Simplified Procedures for Water Examination - Laboratory Manual by American Water Works Association - AWWA, 6666 W. Quincy Ave., Denver, CO 80235

2. Surface Water Treatment Workshop Manual.

   Publications Center, Ministry of Government Services, 3rd Basement level, Mac Donald Block, Queen's Park, Toranto, Ontario M7A IN8. Order must be accompanied by a check. The approximate cost in U.S. dollars is $3.50.

JAR TEST

INTRODUCTION

The jar test is used to determine the proper chemical dosage required for good coagulation and flocculation. The test is commonly used in potable water, secondary effluent prior to Advanced Wastewater Treatment, secondary clarifier influent, and sludge conditioning practice.

The jar test procedure requires the addition of various dosages and combinations of chemicals into beakers which are stirred in a manner which as closely as possible duplicates plant performance.

After stirring, the mixtures are observed and the best condition selected. This conditon then becomes the central point for other chemical combinations that allow the operator to zero in on the exact chemical combination and dosages necessary. This could require several trails.

Many items affect the chemical combinations and dosages required for proper coagulation and flocculation. These include:

1. pH of the water
2. Turbidity
3. Water temperature
4. Amount and type of alkalinity
5. Color of the water
6. Type of chemicals
7. The amount of mixing
8. Order that chemicals are added
9. The type of mixing

Of these items the most critical are pH, temperature, and turbidity. The alkalinity value becomes important when the total alkalinity of the water is below 80 mg/l. When this occurs the addition of small amounts of primary coagulants may cause a depression in the pH.

EQUIPMENT

Variable speed (0 - 100 rpms) gang stirrer with 4 to 6 paddles
Laboratory time
4 to 6 1 liter beakers
One 1 liter graduated cylinder
1, 5, 10, and 20 ml measuring pipets
1 sample container - 5 gallon minimum volume
Pipet bulb

REAGENTS

The reagents should be samples taken from those chemicals that are fed (or to be fed) at the facility.

SOLUTION PREPARATION

STOCK SOLUTIONS

The stock solutions are those that will be added to each beaker during the test. Stock solutions should be prepared at a concentration so that all of the 1 liter beakers can be dosed from a single pipet filling.

Chemicals used to prepare these stocks should come from those that are being fed at the plant.

Four types of chemicals are normally fed:

1. Dry chemicals - fed directly.
2. Concentrated solutions - fed directly.
3. Dry chemicals that are batch mixed prior to being fed.
4. Liquid chemicals that are batch mixed prior to being fed.

Desired stock solutions concentrations can be selected from the table below. For details in preparation of stock solutions see the student workbook.

Approx. Dosage Required, mg/l	Grams/Liter to Prepare	1 ml Added to 1 Liter Sample Equals	Stock Solution Conc., mg/l (%)
1 - 10 mg/l	1 g/l	1 mg/l	1,000 mg/l (0.1%)
10 - 50 mg/l	10 g/l	10 mg/l	10,000 mg/l (1%)
50 - 500 mg/l	100 g/l	100 mg/l	100,000 mg/l (10%)

PROCEDURE

1. COLLECT SAMPLE.

   At least 5 gallons of sample should be collected and delivered to the lab within 15 minutes.

2. CHECK pH, ALKALINITY, TEMPERATURE AND TURBIDITY.

   This data should be recorded on the data sheet.

3. SELECT STOCK SOLUTIONS.

   Past experience or manufacturers recommendations may indicate the primary coagulant to start with. If the alkalinity is below 80 mg/l and expected dosages are greater than 20 mg/l for Alum then some source of alkalinity must be added. (Soda ash, lime or sodium bicarbonate).

4. SELECT A DOSAGE RANGE.

   This may be found by contacting other plants that are treating the same type of water or by just an educated guess. It doesn't make any difference where you start. Only keep in mind that if you are close to optimum when you start you will save time. A typical range for potable water might be 10 to 60 mg/l in 10 mg/l steps.

5. MIX RAPIDLY.

   Try to duplicate the rapid mix of the plant. Usually a mix of 100 rpm.

6. ADD CHEMICALS.

   While the rapid mix continues, add chemicals to each beaker in order and dosages previously determined. The chemicals should be added as rapidly as possible, so that the start time for each beaker is about the same.

7. CONTINUE RAPID MIX.

   Duplicate plant rapid mix detention time (20 seconds to 5 minutes).

8. MIX SLOWLY.

   Slowly decrease stirrer speed to duplicate plant floc basin. Usually approximately 5 rpm. Continue for 15 to 30 minutes. Again try to duplicate plant floc basin detention time.

9. SHUT OFF MIXER

   and raise the stirrers.

10. ALLOW FLOC TO SETTLE.

    Observe settling speed and record observations.

11. MAKE OBSERVATIONS.

    Observe and record floc size, appearance and general action.

12. MAKE READINGS.

    Test supernatant for pH and turbidity. If test is being conducted for sludge conditioning siphon off supernatant and test sludge for filter leaf, capillary suction time, and specific resistance.

13. REPEAT AS NECESSARY.

    When the slow stirring is completed one of four conditions will usually prevail:

    1. No floc in any of the beakers.
    2. Good floc in all beakers.
    3. One jar with weak floc.
    4. A range from no floc to floc.

    Each of these conditions requires a slightly different approach and are discussed in the student workbook. However, generally the process is to try to hold all parameters except one steady and vary that one until it's at its best point. Then vary a second parameter and so forth until the best quality floc is produced.

SUPPLEMENTARY MATERIALS

PREPARATION OF STOCK SOLUTIONS

Chemicals are feed in any one of these ways:

1. Dry chemical feed - fed directly.
2. Concentrated liquid solutions - fed directly.
3. Dry or liquid chemicals that are mixed in a batch and then fed from the batch.

In order to have the jar test be reliable it is important that the chemicals that are being used in the test be representative of the chemicals that are being fed. To do so requires making stock solutions directly from the feed chemicals. Each time a new batch of chemicals are received a jar test should be performed with these chemicals. This will allow you to make adjustments for slight changes in chemical concentrations.

This process often requires the application of simple dilution techniques; however, these simple techniques are not all that simple when you try to apply them. Therefore, we have devised the following work aids to simplify the procedure. If you wish to obtain more information regarding exactly what is happening at each dilution step refer to Appendixes A, B, and D of the instructor's guide.

STOCK SOLUTION FROM DRY CHEMICALS

This is the most straight forward and requires making a stock based on anticipated dosage needs. The following table can be used to help determine the proper concentrations.

Approx. Dosage Required, mg/l	Grams/Liter to Prepare	1 ml Added to 1 Liter Sample Equals	Stock Solution Conc., mg/l (%)
1 - 10 mg/l	1 g/l	1 mg/l	1,000 mg/l (0.1%)
10 - 50 mg/l	10 g/l	10 mg/l	10,000 mg/l (1%)
50 - 500 mg/l	100 g/l	100 mg/l	100,000 mg/l (10%)

STOCK SOLUTION FROM CONCENTRATED SOLUTIONS

Solutions of Alum, Ferric Chloride, Ferric Sulfate and other concentrated solutions require the use of the specific gravity of the solution. If the specific gravity (sp. gr.) is not known it can be found by weighing a known volume at the solution, and comparing that weight to the weight of an equal volume of water. 10 ml of H_2O would weigh 10 grams. So if 10 ml of some other solution weighs 13.5 grams then the sp. gr. of the solution is:

$$\frac{13.5 \text{ grams solution}}{10 \text{ grams water}} = 1.35$$

The amount of this concentrated solution needed can be found by the following formula:

$$\text{ml of conc. needed} = \frac{\text{\_\_\_\_\_\% stock X \_\_\_\_\_ volume, ml stock}}{\text{\_\_\_\_\_ specific gravity X \_\_\_\_\_ \% conc.}}$$

STOCK SOLUTION FROM BATCH MIX DRY FEEDERS

Determine the concentration of the mixed batch solution. If this is not known use the following formula:

$$\frac{(\quad) \text{ lbs of chemical X } 1{,}000{,}000}{(\quad) \text{ gal of } H_2O \text{ X } 8.34} = \text{\_\_\_\_\_ mg/l}$$

Select a required dosage from the table below:

Approx. Dosage Required, mg/l	Stock Solution Conc. Needed, mg/l	1 ml Added To 1 liter Sample Equals
1 - 10 mg/l	1,000	1
10 - 50 mg/l	10,000	10
50 - 500 mg/l	100,000	100

Compute the volume of solution needed to make 1 liter of stock.

$$\text{Volume of Batch Mix, ml} = \frac{(\quad)\text{conc. of stock needed mg/l X } 1{,}000 \text{ ml}}{(\quad)\text{conc. of batch mix, mg/l}}$$

Place volume of batch in 1 liter volumetric flask and dilute to 1 liter with distilled water.

STOCK FROM LIQUID BATCH

If the concentration of the liquid batch is known go on to the second formula; if it is not, calculate as follows:

$$(\quad)\ \text{conc., mg/l} = \frac{(\quad)\ \text{gal. of chemical X 1,000,000}}{(\quad)\ \text{gal of container}}$$

Determine the desired dosage in the sample. If you have no idea, pick a common value. Typical values are:

1 ml added will give 1 mg/l dosage,
10 mg/l dosage or 100 mg/l dosage.

After making this determination select the required concentration of stock from the table given with the dry chemical procedure or calculate as follows.

$$(\quad)\ \text{conc., stock mg/l} = \frac{(\quad)\text{volume of sample, ml X } (\quad)\ \text{dosage, sample, ml}}{(\quad)\text{volume of stock transferred to sample, ml (usually 1 ml)}}$$

Now calculate the volume of batch necessary.

$$(\quad)\ \text{batch, ml} = \frac{(\quad)\ \text{conc. of stock mg/l X 1,000 ml}}{(\quad)\ \text{cons. of batch, mg/l}}$$

THE THEORY OF COAGULATION AND FLOCCULATION

At various points in the treatment of water and wastewater we find that there is small particulate matter that we would like to remove but cannot do so by normal physical means. Whenever we run into this circumstance it usually calls for the addition of chemicals that cause coagulation and flocculation.

Why would we want to remove these solids and under what circumstances? In water treatment we are often faced with the situation of the removal of turbidity and color. With wastewater, there is the need, at times, to reduce the suspended solids level in secondary effluents. We can use this process to reduce phosphorus levels. We can also use the process to enhance the settling of activated sludge in the secondary clarifier. And when we're dealing with sewage sludges we can use the process to enhance dewatering. In this case it is called conditioning.

One of the basic questions that we come up to, then, is "Why won't these materials (that is, the materials that form turbidity, color and the solid and that sort of thing), settle normally using gravitational forces?" In order to get a basic understanding of that, we need to take a look at, first of all, the forces that tend to keep the stuff from settling. At the same time, there are some forces that tend to help things settle. The forces that cause things to settle are called instability forces. The forces that keep them from settling are called stability forces.

Let's look first at the forces of stability. First of all, one of the items that gets in the way here is size.

DIAMETER OF PARTICLE, mm	ORDER OF SIZE	TOTAL SURFACE AREA	TIME REQUIRED TO SETTLE
10	Gravel	0.487 sq in.	0.3 sec.
1	Coarse sand	4.87 sq in.	3 sec.
0.1	Fine sand	48.7 sq in.	38 sec.
0.01	Silt	3.38 sq ft	33 min.
0.001	Bacteria	33.8 sq ft	55 hr.
0.0001	Colloidal particles	3.8 sq yd	230 days
0.00001	Colloidal particles	0.7 acres	6.3 yr.
0.000001	Colloidal particles	7.0 acres	63 yr minimum

Figure 1 shows particle diameter in millimeters, names for the types of particles, and settling times for particles of that size. We don't run into much trouble until we get down in the neighborhood of the 0.001 millimeters in diameter. Notice that these will settle one foot in about 55 hours. And from there on down we begin to run into problems. You can see that when we get into the colloidal particle area we're talking about a minimum of 230 days up to as much as 63 years to settle. So the size of the particle is extremely important to our ability for it to settle out.

Secondly, there is the specific gravity. As we learned earlier, specific gravity of sewage is almost 1. Now, specific gravity of water is exactly 1. Sewage is just slightly greater than 1 most of the time. So there would be a number of times that it might not settle.

Thirdly, there is the nature of the particles. That is, what are the particles made up of? And basically, when we get into colloidal particles we have to take a look at the surface phenomena or surface charges of these particular particles. Now, colloidal particles are those particles

that are less than 0.001 millimeters (1 micron) in size. The kinds of phenomena we're looking at here fall into two areas - a group of phenomena called hydrophobic and then a phenomena called hydrophilic.

Hydrophobic particles are mostly inorganic. They're basically clay particles and they usually contribute to turbidity. On the other end of the spectrum is a group of particles we call hydrophilic, that are basically organic particles and contribute to color. The hydrophobic particles usually remain in solution or don't settle because of an electrical charge on their surfaces. This electrical charge is mostly negative. It's interesting, also, to note that most microorganisms also have a negative electrical charge on their surface.

The hydrophilic particles, (hydrophilic stands for water-loving) are basically organic material. Because they are organic, they also can have some surface charges. The surface charges are relative to the type of material. So, just as a result of the compound that makes up the organic material, such as carboxyl or hydroxyl ions in that compound, an electric surface charge results. The charge could be positive or it could be negative. But most of the time the charge is negative.

There is another phenomena here, also part of this hydrophilic group of materials, and that's where a particle is covered with a layer of water. We call that layer water hydration. The water may already be chemically combined with ions which produce positive or negative charges. Also, if the particle itself were charged, remember that water molecules are polar and they could arrange themselves on the

particle to create an electrical charge.

Why are those important to keeping materials in solution? First of all, the hydrophobic particles, because they are all negatively charged, tend to repel one another. As a result, you can't get those two particles to come togehter. If we can get them to come together and touch and stick, they might be able to get large enough to settle out.

By the same token the hydrophilic particles will not come together for a couple of reasons. It could be because of electrical charges but it also could be just because of the layer of water. The layer of water around the two particles won't let the two particles come close enough together to touch and stick and settle out. These are basically the forces that tend to keep small particles suspended in solution. We have size, specific gravity and the nature of the material, whether it's hydrophobic or hydrophilic.

We've already mentioned to some of the instability factors. One of those is that when particles are extremely small in diameter they are bumped into by water molecules and that causes them to continually move around. As water temperature increases the particles in the water move faster and, therefore, the material is more likely to remain indispersed. This action is called the Brownian movement.

There is another phenomena called the Van der Waal's forces. Anytime we're dealing with atomic particles, they have some attraction to one another. If we could get two small particles to get close enough together, this attractive force would continue to pull them together

and they would stick forming larger and larger particles and when we get enough of them together they would actually settle. So, one of the reasons that the Brownian movement is important is that we can get these particles moving around and if they bump into one another hard enough to overcome those force of stability they'll stick together and get large enough to settle out.

Most of the time we find in waters that we really don't have hydrophobic and hydrophilic particles, as such. What we have is a heterogeneous mixture of these things. Bits and pieces of clay attached to some organic material and some microorganisms. In wastewater we've got a group of organic flocs. We would like to reduce the stability forces and enhance the instability forces. The reduction of the stability forces is called coagulation. And basically that can take place by the addition of chemicals called primary coagulants.

The most common primary coagulants are salts of aluminum and iron. Aluminum sulfate, commonly called alum, is probably the most common primary coagulant. There's also one called sodium aluminate. And then there are three very common iron salts, ferric sulfate, ferrous sulfate and ferric chloride.

When we add these coagulants to water, insoluble aluminum or ferric hydroxide results. Aluminum and iron coagulants act similarily. Let's deal with aluminum. The aluminum hydroxide is made by the addition of the aluminum sulfate which combines with the alkalinity that's in water.

The result is twofold. First of all, we've formed a weak acid in aluminum hydroxide. Secondly, we have used some alkalinity. Typically, one milligram per liter of alum will use about 0.5 milligrams per liter of natural alkalinity in forming the aluminum hydroxide. The combination of those two items can, in low alkalinity waters, (less than 80 milligrams per liter) tend to lower the pH of the solution. The resulting reaction of the forming of aluminum hydroxide is that the aluminum hydroxide is extremely positively charged. Those positive charges can be absorbed on the surface of hydrophobic particles and, thus, have a tendency to reduce their overall electrical charge. They don't even have to be absorbed. If they're just in the solution close to the hydrophobic particles they will have a tendency to reduce the overall electrical charge. This would allow those hydrophobic particles to be brought together by the Brownian movement. If they contact each other they'll stick and we can get a number of them stuck together as a result of the Van der Waal's forces. They will probably be large enough to settle. It's not required that we totally overcome the electrical negative charge that's on the hydrophobic particles, just that we reduce it enough so that the stuff can stick together.

With the hydrophilic particles, there are some other things that happen. First of all, we might get the material to combine chemically with hydroxyl and carboxyl or phosphate groups that are in the water around the particle. This would have a tendency to reduce the electrical charge, also. There also can be some chemical combinations of aluminum

hydroxide with other substances that are in the water, specifically the alkalinity. And this can form a sticky substance which might happen right on the surface of the hydrophobic or hydrophilic particles. That, in itself, is called coagulation.

Because by reducing those electrical charges and forming the sticky material we have now overcome some of the major stability forces. So the chemical process of overcoming those stability forces is called coagulation.

We talked about alum and iron salts as being primary coagulants. Oftentimes, we use polyelectrolytes, which are just long-chain, organic molecules that can either be positively or negatively charged or have enough charges of equal size that they are basically neutral. We can use these, in some instances, as primary coagulants.

Once we have overcome the stability forces, if we stir the solution and cause these particles to bump together, we can cause the formation of floc and increase its size to the point that it will settle. That physical phenomena of mixing and bumping together and sticking of these particles is called flocculation.

There are a number of factors that influence our ability to coagulate. One of them is the order in which chemicals are combined in a solution. For instance, we may be having to add chlorine and a polyelectrolyte and a primary coagulant. The order in which they go in may affect or influence coagulation. Probably the single most important item is pH. We'll come back to that in a moment.

Temperature influences coagulation. As the temperature goes down, and it doesn't have to drop very much, like 5 to 10 degrees, then we change the amount of chemicals that are needed in order to get coagulation.

The presence of salts of sodium, calcium and magnesium also can affect our ability to coagulate. The kinds of things that they do are alter the pH range that we coagulate in, alter the time it takes to get flocculation to take place, and alter the amount of coagulant that it takes to get the job done.

The amount of turbidity or the amount of solids that are present also affect the amount of chemical that is added and, therefore, affect coagulation. Usually, as the solids concentration goes up we also need to increase the amount of coagulant that we feed.

The type of chemical we feed is important. Aluminum salts have a narrow pH range. Iron salts have a wide pH range.

Let's take a closer look at pH because it is the single most important factor. What we want is for the addition of our primary coagulants to be such that they are insoluble. We do not want them to be soluble because if they are soluble they are going to just pass right on through the facility and not form a floc. The pH range in which they are soluble is relatively narrow. So, if we do things to affect the pH that will affect our ability to have insoluble aluminum hydroxide. It will also affect the amount of coagulant that it takes to get the job done.

Besides the primary coagulants there are a few other items of importance. Usually we talk about these as aids. We may want to add some oxidants, like chlorine or potassium permanganate. Basically, these things

would change the nature of organic compounds. They are usually applied prior to coagulation. With some waters it's nearly impossible to get coagulation without the addition of some oxidant. We don't really understand exactly what the oxidant does but we know that it does alter the organic compounds.

We may want to add weight to the floc to get it to settle. We can do that with such things as bentonite clay, silica and activated carbon and some of the polyelectrolytes. We may want to use polyelectrolytes to add strength to the floc, to add weight, to increase the rate in which the floc is formed. As was mentioned earlier, there are three kinds of polyelectrolytes: anionic, cationic and nonionic. That is, there is negatively charged, positively charged and neutral charged polyelectrolytes.

The last item that we need to consider is the alkalinity. In most parts of the country a consideration of alkalinity is not really important. But there are some areas of the United States, particularly in the Northwest and the Northeastern Coast, where a lot of the waters have extremely low alkalinity. By low, I mean they may be as low as 20 to 30 milligrams per liter. Often we find that when the alkalinity of water is below 80 milligrams per liter, the addition of any of the primary coagulants will tend to cause the pH to drop. Often the result is to move the solution out of the optimum pH range for coagulation. When you have these low alkalinity waters you're probably going to need to add some alkalinity to the water in order to get coagulation to take place.

There are basically four different types of alkalinity that we can add. We can add quick lime (CaO). 85% quick lime will add about 0.33 milligrams per liter of alkalinity for each 1 milligram per liter of primary coagulant. We can add hydrated lime or we could add soda ash.

THE JAR TEST

Whenever there is a need to feed chemicals in a water/wastewater facility in order to promote coagulation and flocculation there is always the frustration of how much chemical to feed and where to feed it. Probably the most classic means of determining proper chemical dosages is the jar test. With the jar test we try to duplicate, as closely as possible, actual plant conditions of the amount of chemicals, the type of chemicals, and the order in which they are added.

We need to keep in mind that there are many factors that affect chemical combinations and dosages that are required for coagulations and flocculation. Amoung these would be pH of the water, the turbidity, the temperature of the water, the amount and type of alkalinity present, the color of the water, the types of chemicals or salts that are present, the amount and degree of mixing that takes place, and the order in which chemicals are added. Probably, of all these items, the most critical of course is pH, temperature, and turbidity. Alkalinity, as you remember, only becomes important when we're dealing with low alkalinity waters; that is, waters below 80 mg per liter.

The equipment that we need to do this test is a four or six paddle gang stirrer, a laboratory timer, four to six 1 liter or 1500 milliliter beakers, at least one, 1 liter graduated cylinder, some one, five, ten, and twenty milliliter measuring pipets, and a clean sample container in which we can collect at least 5 gallons of sample.

This test procedure has four basic steps: the preparation of reagents, the collection of a sample, the test itself, and then recording and observation of the results.

The first step is the preparation of the reagents. Keep in mind that the reagents that we're using should be made up from samples of the chemical that are actually being fed in the facility; or if it's chemicals that you're wanting to try, they should be from the stock of chemicals that you intend to feed.

What we need to do is prepare a stock solution. The stock solution that we want to prepare needs to be of a concentration that will allow us to be able to dose all of the beakers from a single pipet full. In other words, I want to get the pipet full once and I want to dose all six of these beakers and not have to go back and refill the pipet to do so.

TABLE 2

Approx. Dosage Required, mg/l	Stock solution Conc., mg/l (%)	Grams/Liter to Prepare	1 ml Added to 1 Liter Sample Equals
1-10 mg/l	1000 mg/l(0.1%)	1 g/l	1 mg/l
10-50 mg/l	10,000 mg/l (1%)	10 g/l	10 mg/l
50-500 mg/l	100,000 mg/l (10%)	100 g/l	100 mg/l

Table 2 gives us an indication of the kinds of concentrations that we need. For instance, if we feel that our test dosages need to be in the 10 to 50 mg/l range then we need to make up a solution that is 10,000 mg/l concentration or about 1%. What that really means is that if I add one milliliter of that stock solution to a one liter beaker that concentration is ten mg/l.

Now, keep in mind that there are four types of chemicals that we normally feed. There are dry chemical feeders that just feed the dry chemicals directly. There are concentrated solutions we can buy such as alum and ferric sulfate and just feed the solution. There are dry chemicals that we mix up into a batch container and feed out of that batch container with a chemical feed pump. And there are liquid chemicals that we purchase and mix up into a batch and feed with a chemical feed pump. Refer to the supplementary materials for details on stock solution preparation.

The next item is to collect the sample. Now, we need to collect the sample from the point at which we intend to inject chemicals. Collect at least 5 gallons of sample. Try to maintain the sample at the same temperature in the lab as it was in the facility. If it is cool outside then we may want to set the excess amount of sample outside while we're doing the first portion of the test.

Now, let's take a look at the test procedure. The first thing that we want to do is take a portion of the sample and check for pH, alkalinity, temperature and turbidity, then record these on the data sheet.

Next select a stock solution. If you don't know what type of chemicals to feed then maybe we would want to check with another facility, or the engineer who designed the facility, or the manufacturer of chemicals. You need to select a dosage range. You remember we just did that previously when we were talking about preparing the stock solution. The clearer the water the smaller the dosage range. The more solids we have in the water usually the greater the amount of chemicals we want to feed. If we're doing conditioning for sewage sludges we may be having to feed 200 to 300 mg/l of alum in order to get a good floc. If we're dealing with relatively clear drinking water then it might be somewhere in the neighborhood of 10 to 60 mg/l.

Once we have selected a solution and selected a dosage range then fill each of the 1 liter containers with sample. Measure out a liter and pour it in one of the six beakers. Use a pen that will wipe off with water to write the desired dosages right in front of the beakers. Next, drop the paddles down and start the rapid mix. Mix at about 100 rpm or if you can duplicate what's going on in the plant then we want to try and do that.

Using a pipet dose each of the containers with the desired dosage. How long we mix them after we dose is relative to what's going on in the plant. Keep in mind what we really want to do is try to duplicate as closely as possible actual plant proceedings. The rapid mix might be anywhere from 20 seconds to 5 minutes. After you've decided that it's mixed long enough then slowly decrease the stirrer to the point that we duplicate the flocculation that's going on in the facility. If you don't know what that is then drop down to about 5 rpm.

Keep the stirrer going anywhere from 15 to 30 minutes but again how long it stirs is relative to what's happening in the plant.

As the floc begins to form we want to record when we first see floc and in which container. Continue observing the floc as the stirring period proceeds. After the stirring or flocculation period, shut off the stirrers and carefully raise them out of the beakers. The floc will start to settle duplicating the sedimentation basin in the plant. During this period observe and record the size of the floc, the settling rate, and the general appearance of the floc. Observe the supernatant (clear liquid above the floc) as the floc settles. Is it clear or turbid? Are small pieces of floc left suspended in the supernatant? Carefully remove some of the supernate and run pH, turbidity, and alkalinity. It is also a good idea to filter some supernatant through coarse filter paper and run these three tests. These observations and tests, run on all beakers, will help you determine which dosage gives the best results.

If we're dealing with sludge conditioning siphon off the supernatant and test the sludge with the filter leaf test, for capillary suction time, and for specific resistance. You may also want to test the supernatant for suspended solids. If the conditioned sludge is to be dewatered by centrifugation you may want to take some of the sludge and spin it down in a clinical centrifuge.

Part of the problem associated with this particular test procedure is what to do at the end of the first run. In the first run we might have

gotten one jar that's good but its bad on either side. We've got one that's got a pretty good floc but we don't know if that's the ideal situation. Now we need to dump all the jars out and refill them and add chemicals to close in on the optimum dosage and conditions. After we've determined optimum primary coagulant dosage we may want to adjust the pH to find the optimum for it.

Let's look at some other things that might have happened in the first run. If you had no floc in any of the beakers then again you'd want to test for pH. If the pH was way down or way up it should be adjusted to about 6.8 to 7.2 (with the exception of trying to get out color, then we need to drive clear down into some acid ranges like around pH 4 or 5). If pH is varied all over the place with these beakers then we need to add some alkalinity to buffer the pH in all the beakers and dose them again. Or it may require a higher dosage in each one of them or a lower dosage. If we've got a good floc in all the beakers, what do we do? Again check for pH, let them settle, check for turbidity, find the ones that are best and do a little bit of adjustment on them.

We've got one jar with a weak floc. What do we do? Well, take that one jar and, again check the pH of everything and adjust the chemicals one at a time holding everything steady and making one adjustment at a time until we zero in. It could take you all day on one water supply or one sludge sample, to get the best combination of chemicals.

JAR TEST DATA			
DATE		SAMPLE LOCATION	
TIME		SAMPLER	
ANALYST		TIME OF TEST	
INITIAL DATA			
TURBIDITY	TU'S	COLOR	HAZEN UNITS
pH	TEMPERATURE	°F	°C
ALKALINITY	mg/l		mg/l
	mg/l		mg/l

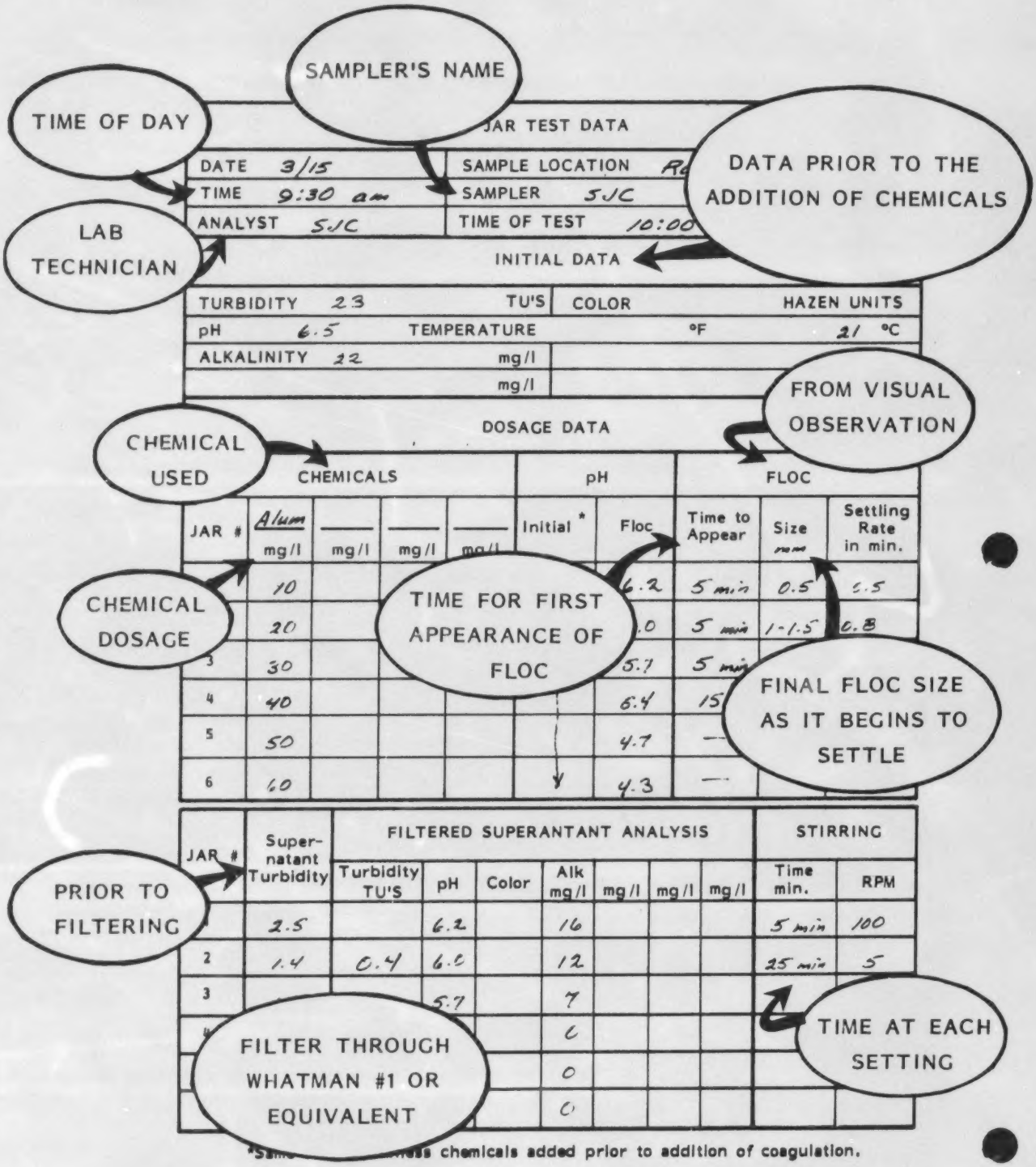
DOSAGE DATA

	CHEMICALS				pH		FLOC		
JAR #	——— mg/l	——— mg/l	——— mg/l	——— mg/l	Initial *	Floc	Time to Appear	Size	Settling Rate in min.
1									
2									
3									
4									
5									
6									

JAR #	Super-natant Turbidity	FILTERED SUPERANTANT ANALYSIS							STIRRING	
		Turbidity TU'S	pH	Color	Alk mg/l	mg/l	mg/l	mg/l	Time min.	RPM
1										
2										
3										
4										
5										
6										

*Same as raw, unless chemicals added prior to addition of coagulation.

SAMPLE DATA SHEET


SAMPLER'S NAME
TIME OF DAY
LAB TECHNICIAN
DATA PRIOR TO THE ADDITION OF CHEMICALS
FROM VISUAL OBSERVATION
CHEMICAL USED
CHEMICAL DOSAGE
TIME FOR FIRST APPEARANCE OF FLOC
FINAL FLOC SIZE AS IT BEGINS TO SETTLE
PRIOR TO FILTERING
FILTER THROUGH WHATMAN #1 OR EQUIVALENT
TIME AT EACH SETTING

JAR TEST DATA

DATE 3/15	SAMPLE LOCATION Re
TIME 9:30 am	SAMPLER SJC
ANALYST SJC	TIME OF TEST 10:00

INITIAL DATA

TURBIDITY 23	TU'S	COLOR	HAZEN UNITS
pH 6.5	TEMPERATURE	°F	21 °C
ALKALINITY 22	mg/l		
	mg/l		

DOSAGE DATA

	CHEMICALS				pH		FLOC		
JAR #	Alum mg/l	____ mg/l	____ mg/l	____ mg/l	Initial *	Floc	Time to Appear	Size mm	Settling Rate in min.
1	10					6.2	5 min	0.5	1.5
2	20					.0	5 min	1-1.5	0.8
3	30					5.7	5 min		
4	40					6.4	15		
5	50					4.7	—		
6	60				↓	4.3	—		

JAR #	Super-natant Turbidity	FILTERED SUPERANTANT ANALYSIS							STIRRING	
		Turbidity TU'S	pH	Color	Alk mg/l	mg/l	mg/l	mg/l	Time min.	RPM
1	2.5		6.2		16				5 min	100
2	1.4	0.4	6.0		12				25 min	5
3			5.7		7					
					0					
					0					
					0					

*Same as ... unless chemicals added prior to addition of coagulation.

PROCEDURE SUMMARY

1. Collect 5 gallons of sample.
2. Deliver to the lab in 15 minutes.
3. Check pH, alkalinity, and temperature.
4. Select stock solution.
5. Select a dosage range.
6. Rapid mix @ 100 RPM's.
7. Apply chemicals.
8. Wait 5 minutes.
9. Slow stir 15 to 30 minutes.
10. Observe and note floc formation time.
11. Shut down.
12. Make observations
    a) floc size
    b) settling time
13. Perform analysis of supernatant.

JAR TEST

The above procedure summary is designed as a laboratory aid. It may be cut out and attached to a 5" X 7" index card for convenient reference at the laboratory bench. To protect the card you may wish to cover it, front and back, with clear, self-adhesive shelf paper or similar clear material.

JAR TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. In order to perform the jar test you should collect a sample volume of:

   a)_____ 2 1/2 gallons.
   b)_____ 5 gallons.
   c)_____ 2 1/2 liters.
   d)_____ 5 liters.
   e)_____ All of the above.

2. When the actual plant data is not available, flash mix in the jar test should be for how much time?

   a)_____ 5 minutes
   b)_____ 10 - 30 seconds
   c)_____ 5 - 30 minutes
   d)_____ 1 - 8 minutes
   e)_____ None of the above.

3. Which one of the following is in correct sequence?

   a)_____ Turn on the flash mix, then add chemicals.
   b)_____ Add the chemicals then turn on the flash mix.
   c)_____ Slow stir then flash mix.
   d)_____ Flash mix then slow stir.
   e)_____ All of the above.

4. When plant data is not available, the slow stir time should be approximately:

   a)_____ 10 - 30 seconds.
   b)_____ 30 - 60 minutes.
   c)_____ 20 - 40 minutes.
   d)_____ 15 - 30 minutes.
   e)_____ All of the above.

5. A low alkalinity water is one in which the alkalinity is below:

a)_____ 40 mg/l.
b)_____ 7 grains/gallon.
c)_____ 150 mg/l.
d)_____ 80 mg/l.
e)_____ None of the above.

6. Which item is the most influencial in determining the proper chemical dosage?

a)_____ Alkalinity
b)_____ pH
c)_____ Temperature
d)_____ Presence of salts
e)_____ None of the above.

7. Normally, as the solids concentration or turbidity of water increases the amount of chemicals necessary to obtain adequate coagulation:

a)_____ stays the same.
b)_____ goes up.
c)_____ goes down.
d)_____ can go either up or down.
e)_____ None of the above.